

Self-lubrication naturally led to the whole of the moving parts being enclosed, giving obvious advantages from the point of view of cleanliness, with reduced risk of grit and dirt finding their way to the wearing surfaces.

The Willans engine was of the single-acting type, and provided with a device for keeping the connecting-rod in " constant thrust ", so that there was little tendency for " knocking " at the crosshead-pin or crank-pin bearings. Consequently the wear was small.

Double-acting engines of the open type had been used for dynamo driving by makers of small naval machinery, such as was used in ship's pinnaces, &c., but the long runs at or about full power required for the generating of electricity caused rapid wear in the bearings with all the attendant inconveniences.

The double-acting type of engine was thus severely handicapped in its usefulness in generating stations and in other situations where a high rotative speed for long periods was required, but a notable invention of Mr. A. C. Pain, of the firm of Messrs. Bellies & Morcom, of Birmingham, enabled the double-acting engine not only to hold its own but to drive its single-acting rival altogether from the field. This invention, like most others of a really useful character, was very simple, and was founded upon observation of a very common incident. It had been noticed by Mr. Pain that a certain marine engine " bottom end ", which was in need of adjustment and knocking badly, always ran quietly immediately after receiving a supply of oil, but that this improved condition soon disappeared. The deduction was made that if the film of oil periodically renewed from the oil-can could be made permanent, both wear and noise would be, if not altogether prevented, much diminished. An experimental engine on this principle was constructed by Messrs. Belliss & Morcom to Mr. Pain's design, a pump being used to supply the oil to the crank-pin, crosshead-pin, guides, and main bearings, through a specially devised system of oil channels, and the result was entirely successful. Shortly afterwards, the late Mr. Alfred Morcom suggested the employment of a valveless pump of the oscillating

type, and there has been practically no change in the system.

The principle has been applied to all kinds of reciprocating engines, steam and oil, also to the bearings of air compressors and other reciprocating machinery.

Considering what happens in the case of a crank-pin, for instance, it would appear that during the reversals of the direction of driving effort in the connecting-rod, causing relief of pressure on one side of the bearing, the oil film is renewed, and, as there is apparently not time for it to be squeezed out during the succeeding stroke, the rubbing surfaces never come into real contact, the oil in the clearance space acting as a cushion. The wear and noise are consequently negligible, and there are numerous examples of engines of this type which have run for many years and "made millions of revolutions, and in which the wear on crank-pins and main bearings, &c., has been only just detectable by careful gauging.

It is impossible, however, to omit due recognition of the merits of the